The University of Sydney

AUSTRALIA

School of Electrical and Information Engineering

Advanced Communication Networks

Chapter 10

Broadband ISDN: Architecture and Protocols

Based on chapters 14-15 of Stallings ISDN-4e book

Abbas Jamalipour

10.1 Introduction

- B-ISDN is a service requiring transmission channels capable of supporting rates greater than the primary rate.
- With B-ISDN services, especially video services, requiring data rates orders of magnitudes beyond those that can be delivered by ISDN will become available.
- These includes support for image processing, video, and high-capacity workstations and local area networks.
- To contrast this new network, the original ISDN network is now referred to as *narrowband ISDN*.

- The key technology developments for B-ISDN are:
  - Optical fiber transmission systems that can offer low-cost, high-data rate transmission channels for network trunks and subscriber lines.
  - Microelectronic circuits that can offer high-speed, low-cost building blocks for switching, transmission, and subscriber equipment.
  - High-quality video monitors and cameras that can, with sufficient production quantities, be offered at low cost.

- Integration of a wide range of communications facilities:
  - Worldwide exchange between any two subscribers in any medium or combination of media.
  - Retrieval and sharing of massive amounts of information from multiple sources, in multiple media, among people in a shared electronic environment.
  - Distribution, including switched distribution, of a wide variety of cultural, entertainment, and educational materials to home or office, virtually on demand.

10.2 B-ISDN Standards

- First CCITT recommendations on B-ISDN were issued in 1998.
  - *I.113*-Vocabulary of Terms for Broadband Aspects of ISDN
  - *I.121*-Broadband Aspects of ISDN
- As a dominant contribution of B-ISDN in ATM networks, ATM Forum had a crucial role in development of B-ISDN standards.

Noteworthy statements in I.113 and I.121

Broadband: A service or a system requiring transmission channels capable of supporting rates greater than the primary rate.

The term *B-ISDN* is used for convenience in order to refer to and emphasize the broadband aspects of ISDN. The intent, however, is that there be one comprehensive notion of an ISDN that provides broadband and other ISDN services.

Asynchronous transfer mode (ATM) is the transfer mode for implementing B-ISDN and is independent of the means of transport at the physical layer.

B-ISDN will be based on the concepts developed for ISDN and may evolve by progressively incorporating directly into the network additional B-ISDN functions enabling new and advanced services.

Since the B-ISDN is based on overall ISDN concepts, the ISDN access reference configuration is also the basis for the B-ISDN reference configuration.

Factors guiding ITU-T work on B-ISDN (I.121)

The emerging demand for broadband services

The availability of high-speed transmission, switching, and signal-processing technologies

The improved data- and image-processing capabilities available to the user

The advances in software application processing in the computer and telecommunications industries

The need to integrate both interactive and distribution services

The need to integrate both circuit- and packet-transfer mode into one universal broadband network

The need to provide flexibility in satisfying the requirements of both user and operator

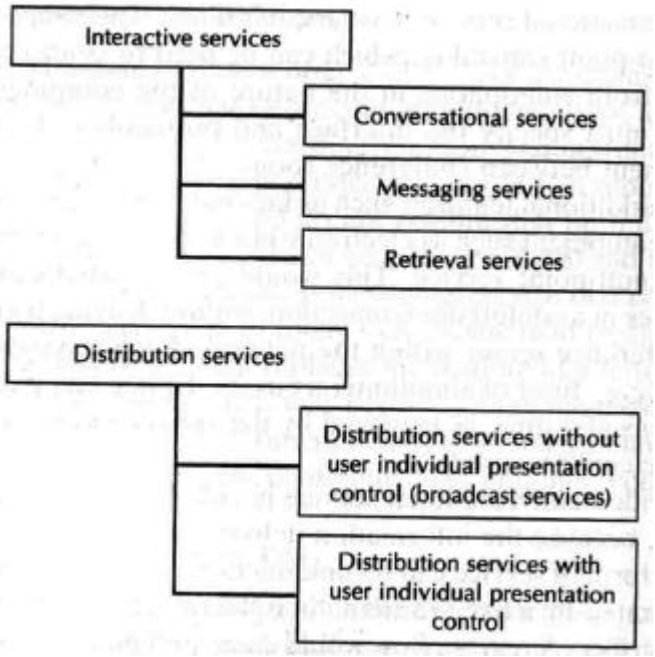
The need to cover broadband aspects of ISDN in ITU-T recommendations

10.3 Broadband Services

- ITU-T classification of B-ISDN services
  - Interactive Services
    - Services in which there is a two-way exchange of information (other than control-signaling information) between two subscribers or between a subscriber and a service provider.
    - Includes: conversational, messaging, and retrieval services
  - Distribution Services
    - Services in which the information transfer is primarily one way, from service provider to B-ISDN subscriber.
    - Includes: broadcast services and cyclical services

Messaging Services

- offer user-to-user communication between individual users via storage units with store-and forward, mailbox, and/or message handling (information editing, processing,conversion) functions.
- Not a real-time service
- Analogous narrowband services of X.400 and teletex
- Video mail is one of services supported by B-ISDN.

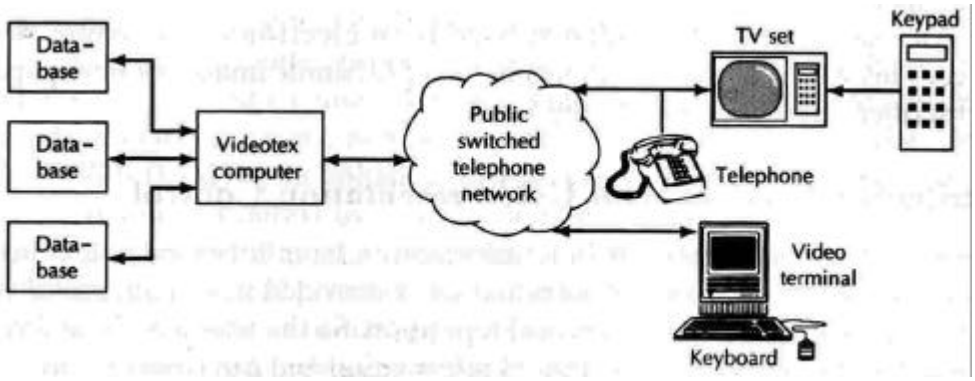


Conversational Services

- provide the means for bidirectional dialogue communication with bidirectional (not store-and-forward), end-to-end information transfer between two users or between a user and a service provider host.
- These services support the general transfer of data specific to a given user application (the information generated by and exchanged between users; not public information).
- Conversational services encompass a wide range of applications and data types including video, data, and document.
- Video conversational services: the most important service
  - Video-telephony (would be the most important service of B-ISDN)
  - Videoconferencing
  - Video surveillance
  - Video/audio information transmission service (higher-quality)
- Data services in B-ISDN
  - File transfer in distributed architecture of computers and storage systems
  - Large-volume or high-speed transmission of measured values or control information
  - Program downloading
  - Computer-aided design and manufacturing (CAD/CAM)
  - Connection of local area networks at different locations
- Document services
  - transfer of very high resolution fax or mixed documents (text, images, voice, video)

Retrieval Services

- provide the user with the capability to retrieve information stored in information centers that is available for public use.
- The information is sent to the user on demand only.
- The information can be retrieved on an individual basis.
- Analogous narrowband service is Videotex.
  - A general-purpose data-base retrieval system for home or office
  - Through the public switched telephone network or cable TV system
  - information in the form of pages of text and simple graphics
- Broadband videotex is an enhancement of the existing Videtex
  - with additional sounds, high-resolution images, short video scenes
  - Examples are:
    - Retrieval of encyclopedia
    - Results of quality tests on consumer goods
    - computer-supported audiovisual entities
    - Electronic mail-order catalogs and travel brochures, order, booking

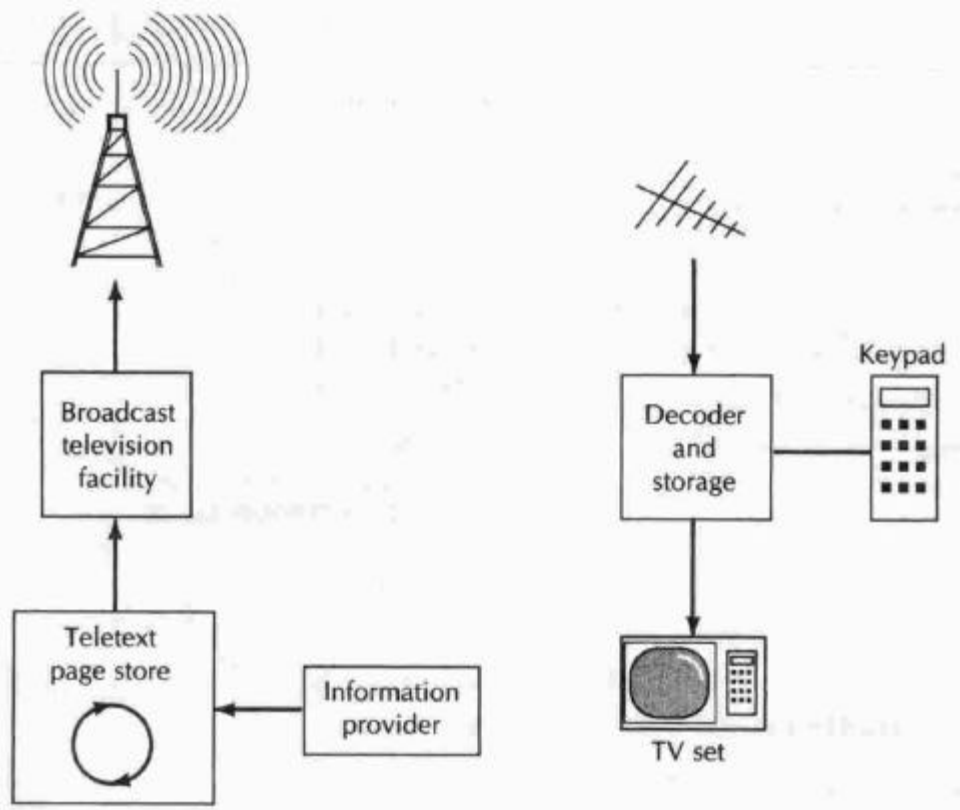


Distribution Services without User Presentation Control

- broadcasting of information from a central source to an unlimited number of authorized receivers connected to network
- access to information without any control over it
- An example is broadcasting television.
  - Broadcasting of higher-resolution via B-ISDN rather than radio waves and cable TV distribution systems.
- Another example is an electronic newspaper broadcast service.
  - Transmission of facsimile images of newspaper pages to subscribers who had paid for the service.

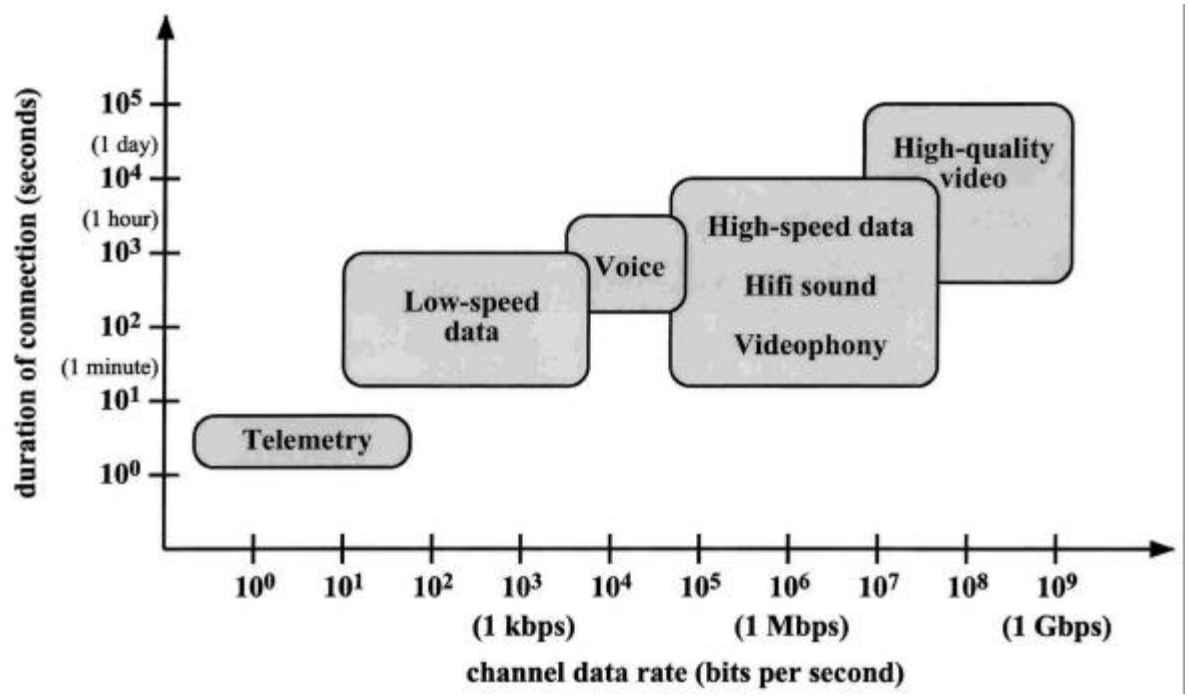
Distribution Services with User Presentation Control

- distributing information from a central source to a large number of users.
- Information are in a sequence of frames with cyclic repetition.
- User can control start and order of presentation.
- Teletext is a narrowband service analogous to *cabletext* of B-ISDN
  - a simple one-way system that uses unallocated portions of the bandwidth of a broadcast TV signal.
  - Transmitter sends pages of text in round-robin fashion.
  - The user keys in the number of desired page and the decoder reads that page from the incoming signal, stores it, and displays it.
  - Limited to few hundred of pages with a cycle time of 10s seconds.
- In Cabletext, full digital broadband channel for cyclical transmission of pages with text, video, audio can be used.
  - Allowing 10,000 pages with a cycle time of 1 second.



10.4 Requirements

- Based on the services provided by B-ISDN, the requirements of transmission structure and especially data rate can be decided.
- Estimation of requirements also needs detailed information on services, including
  - whether, they require constant- or variable-bit rate (CBR/VBR)
  - **burst ratio**: ratio of the time the channel is occupied to the time during which information is sent ® *type of switching technology*
  - error and delay characteristics when ATM cells transmission used
- In some applications, such as video transmission, special techniques would be required to cope their requirements
  - analog video signal requires 6 MHz bandwidth
  - straightforward digitization techniques asks 1Gbps for video Tx
  - to reduce bit rate we can
    - use data-compression techniques that remove redundancy information
    - allow for distortions that are least objectionable to the human eye



Service Type	Service Category	Bandwidth Range	CBR/ VBR	Burst Lengths	Burst Ratio	Cell Loss Tolerance	Cell Delay Tolerance
Voice	PCM voice	64 kbps	CBR	1	N/A	10^{-4} to 10^{-6}	10–150 ms
	ADPCM voice	32 kbps	CBR	1	N/A	10^{-4} to 10^{-6}	10–150 ms
	Predictive coding	16 kbps	VBR	5–15	2–3 KB	10^{-6} to 10^{-8}	10–150 ms
	High-quality voice	192–384 kbps	CBR	1	N/A	10^{-5} to 10^{-6}	10–150 ms
	Voice mail	16–64 kbps	CBR/ VBR	1–3	N/A	10^{-6}	500 ms–5 s
	CD-quality voice	1.4 Mbps	CBR	1	N/A	10^{-6}	500 ms–25 s
	Video teleconferencing/voice part	64–192 kbps	CBR	1	N/A	10^{-7} to 10^{-9}	10–150 ms
Data	LAN interconnection	1.5–100 Mbps	VBR	vary	100–1000 B	10^{-12}	10–100 ms
	Host-host file transfer	64 kbps–1.5 Mbps	VBR	1	12 KB–10 MB	10^{-12}	1–500 s
	PC file transfer	9.6–64 kbps	VBR	1	1 KB–1 MB	10^{-9}	10–100 s
	Client/server system	10–100 Mbps	VBR	1000	1–500 KB	10^{-9}	10–500 ms
	Remote database access	1–10 Mbps	VBR	1000	100 B–100 KB	10^{-9}	1m–10 s
	Remote procedure call	6–60 Mbps	VBR	15–20	60–1000 B	10^{-9}	100 μs–100 ms
	Electronic mail	9.6 kbps–1.5 Mbps	CBR	1	50–5000 B	10^{-9}	1–10 s
	Workstation CAD/CAM	64 kbps–1.5 Mbps	VBR	5	40–100 KB	10^{-9}	1–10 s
	Mainframe CAD/ CAM	1.5–36 Mbps	VBR	10–100	100 KB–1 MB	10^{-9}	10–60 s
	Transaction processing	64 kbps–5 Mbps	VBR	40	100–300 B	10^{-9}	1–3 s
	Time sharing	2.4–64 kbps	VBR	30–100	20–4000 B	10^{-9}	100 ms–10 s
Video	Video telephony	64 kbps–2 Mbps	CBR/ VBR	2–5	2–10 KB	10^{-9}	150–350 ms
	Videoconferencing	128 kbps–14 Mbps	CBR/ VBR	2–5	1.6–40 KB	10^{-9}	150–350 ms
	Video/image mail	1–4 Mbps	CBR	1	64 KB–1 MB	10^{-10}	1–5 s
	Broadband videotex	64 kbps–10 Mbps	VBR	10	> 1 MB	10^{-7} to 10^{-10}	0.1–2 s
	NTSC-quality TV	15–44 Mbps	VBR	2–5	0.5–1.3 MB	10^{-10}	40 ms
	HDTV-quality TV	150 Mbps	VBR	2–5	5–14 MB	10^{-12}	40 ms
	Video browsing	2–40 Mbps	CBR	1	0.5–40 MB	10^{-9}	0.1–2 s
	Group 4 fax (400 × 400)	64 kbps	CBR	1	256–640 KB	10^{-8}	4–10 s
	Medical X-ray (14 × 17 in)	1.5–10 Mbps	CBR/ VBR	25	5–8 MB	10^{-12}	2 s
	Medical MRI/ CAT scan	10–200 Mbps	CBR/ VBR	25	250 kb–3 MB	10^{-12}	2 s
	High-resolution graphics	100 Mbps–10 Gbps	VBR	25	1–100 MB	10^{-12}	10–500 ms

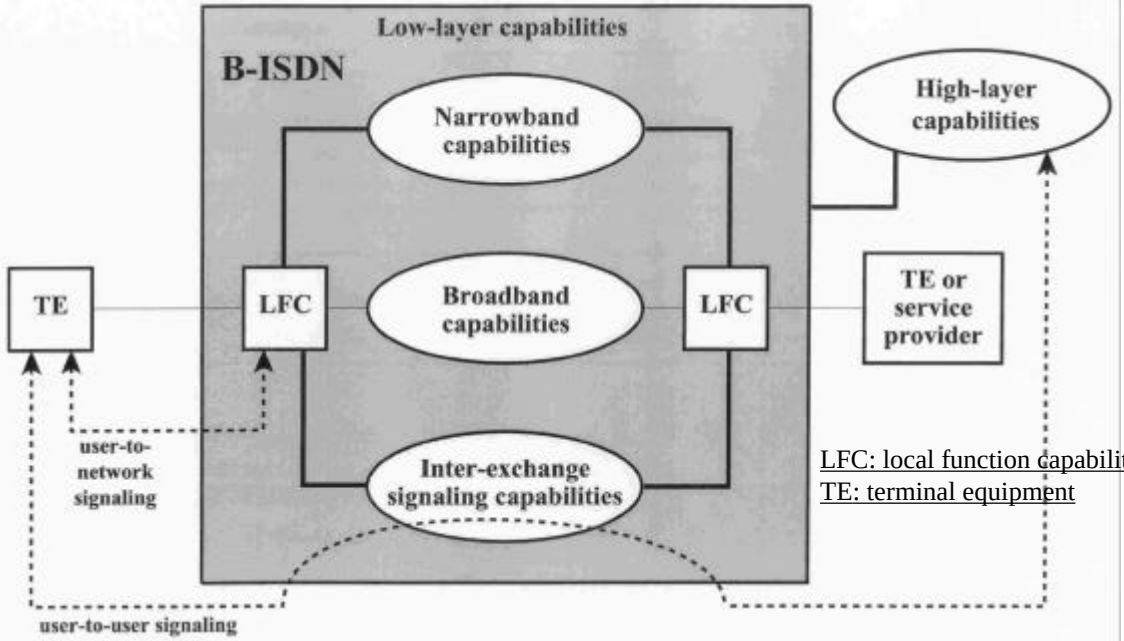
10.5 Architecture

- In B-ISDN, to meet the requirements for high-resolution video, an upper channel rate of about 150 Mbps is needed.
- To support simultaneous services a total subscriber line rate of about 600 Mbps is required.
- Appropriate technology would be the Optical Fiber only.
- Circuit-switching cannot handle such data rates and hence a fast packet switching at user-network interface as ATM is required.
- Principles of B-ISDN and its suggested architecture are in I.121

1. Asynchronous transfer mode (ATM) is the transfer mode for implementing B-ISDN and is independent of the means of transport at the physical layer.
2. B-ISDN supports switched, semipermanent, and permanent point-to-point and point-to-multipoint connections, and provides on demand reserved and permanent services. Connections in B-ISDN support both circuit-mode and packet-mode services of a mono- and/or multimedia type and of a connectionless or connection-oriented nature and in a bidirectional or unidirectional configuration.
3. The B-ISDN architecture is detailed in functional terms and is, therefore, technology- and implementation-independent.
4. A B-ISDN will contain intelligent capabilities for the purpose of providing advanced service characteristics and supporting powerful operation and maintenance tools, network control, and management. Further inclusion of additional intelligent features has to be considered in an overall context and may be allocated to different network/terminal elements.
5. Since the B-ISDN is based on overall ISDN concepts, the ISDN access reference configuration is also the basis for the B-ISDN access reference configuration.
6. A layered structure approach, as used in established ISDN protocols, is also appropriate for similar studies in B-ISDN. This approach should be used for studies on other overall aspects of B-ISDN, including information transfer, control, intelligence, and management.
7. Any expression of network capabilities or change in network performance parameters will not degrade the quality of service of existing services.
8. The evolution of B-ISDN should ensure the continued support of existing interfaces and services.
9. New network capabilities will be incorporated into B-ISDN in evolutionary steps to meet new user requirements and accommodate advances in network developments and progress in technology.
10. It is recognized that B-ISDN may be implemented in a variety of ways according to specific national situations.

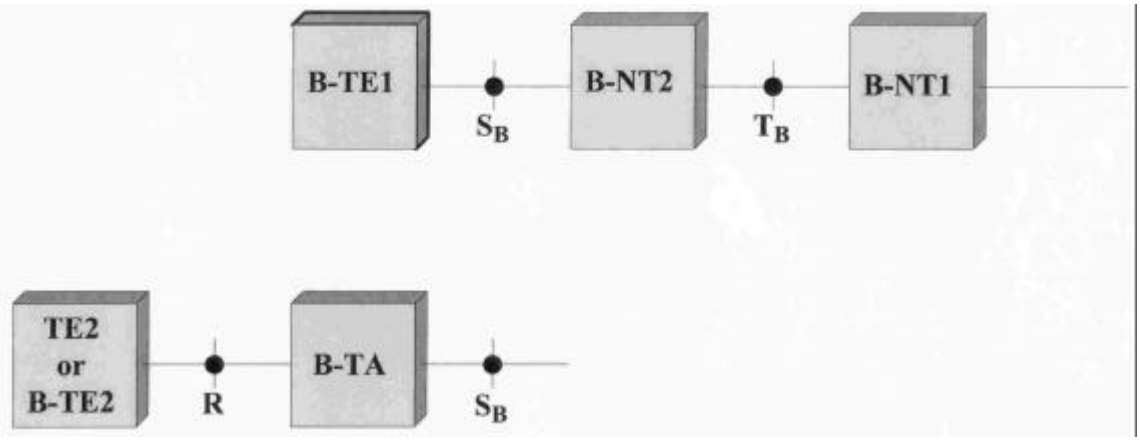
Functional Architecture

- Control of B-ISDN is again based on CCS (SS7).
- The user-network control signaling protocol is an enhanced Q.931.
- B-ISDN must also support narrowband ISDN services (64kbps), both circuit switching and packet switching.
- At user-network interface these capabilities will be provided with the connection-oriented ATM facility.

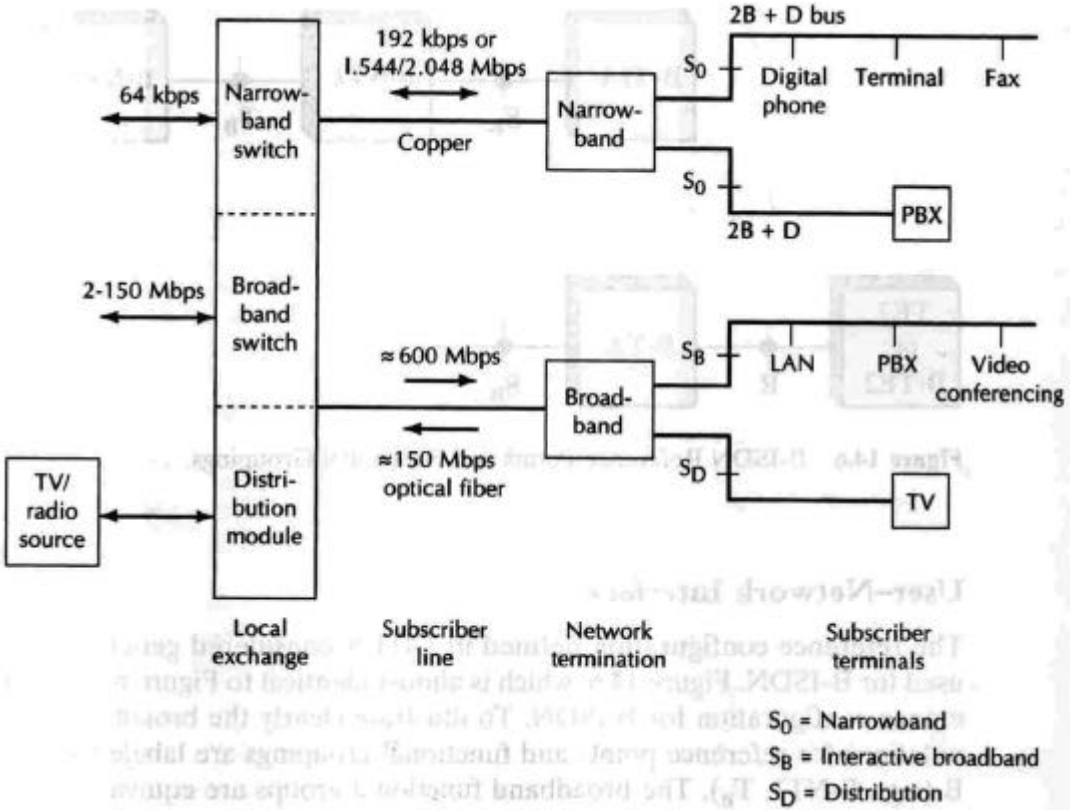


User-Network Interface

- Broadband functional groups are equivalent to those defined in I.411 for narrowband ISDN.
- Interfaces at R reference point may or may not have broadband capabilities.



- Local exchange must handle both B-ISDN and ISDN subscribers.
- ISDN subscribers can have twisted pair connections whereas B-ISDN subscribers may use optical fiber access.
- From network to subscriber a data rate of 600 Mbps is needed, whereas, from subscriber to network a much less data rate of 150Mbps is adequate.

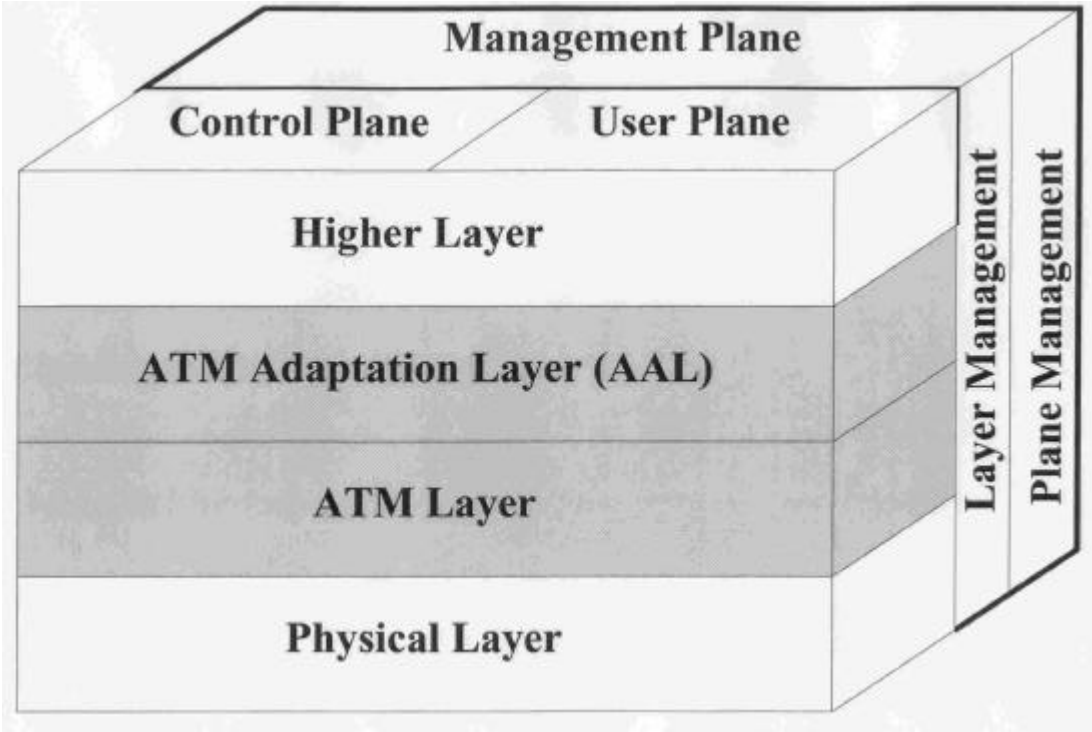


Transmission Structure

- B-ISDN subscribers can have one of three data rates:
  - a full-duplex 155.52 Mbps service
  - asymmetrical: subscriber to network 155.52, other direction 622.08 Mbps
  - a full-duplex 622.08 Mbps service (yet to be defined)
- As 155 Mbps can support all narrowband ISDN services and most of the B-ISDN services, full-duplex 155.52 Mbps is the most common service.
- Full-duplex 622.08 Mbps service would be appropriate for a video distribution provider.
- In new standards of B-ISDN much more flexibility is given, that is the user and network can negotiate any channel capacity that can fit in the available capacity provided by the network.

10.6 B-ISDN Protocol Reference Model

- For B-ISDN, the transfer of information across the user-network interface uses Asynchronous Transfer Mode (ATM).
- One difference between a packet switching network (e.g., X.25) and ATM is that X.25 includes control signaling on the same channel as data transfer, whereas ATM makes use of CCS.
- Another difference is that X.25 packets may be of varying length, whereas ATM packets are of fixed size, called ***cells***.
- Interface and internal switching of B-ISDN is packet-based.
- B-ISDN also supports circuit-mode applications but over a packet-based transport mechanism.
- The protocol reference model has three separate planes:
  - **User Plane:** for user information transfer with flow- and error control
  - **Control Plane:** performs call control and connection control functions
  - **Management Plane:** includes *plane management* (performs management functions related to a system as a whole and provides coordination between all the planes) and *layer management* (performs management functions relating to resources and parameters residing in its protocol entities)



Physical Layer

- consists of *physical medium* and *transmission convergence* sublayers

Physical Medium Sublayer

- includes only physical medium-dependent functions
- thus, depends on the medium used
- timing (synchronization) is one of common functions

Transmission Convergence Sublayer

- Responsible for
  - **Transmission frame generation and recovery**
    - concerned with generating and maintaining the frame structure appropriate for a given data rate at physical layer
  - **Transmission frame adaptation**
    - packaging ATM cells into a frame (e.g., no frame, sending a flow of cells)
  - **Cell delineation**
    - maintaining the cell boundaries so that cells may be recovered after descrambling at the destination
  - **HEC sequence generation and cell header verification**
    - generating and checking cell header's *header error control* (HEC) code
  - **Cell rate decoupling**
    - insertion and suppression of idle cells to adapt the rate of valid ATM cells to the payload capacity of the transmission system

ATM Layer

- independent of physical medium, with the following functions
  - **Cell multiplexing and demultiplexing**
    - having multiple logical connections across an interface similar to X.25 and frame relay
  - **Virtual path identifier and virtual channel identifier translation**
    - VPI and VCI have local significance on logical connections and may need to be translated during switching
  - **Cell header generation/extraction**
    - appending cell header to user data from the AAL
  - **Generic flow control**
    - generating flow control information for placement in cell headers

ATM Adaptation Layer

- consists of *segmentation and reassembly* and *convergence* sublayers
- The **segmentation and reassembly sublayer** is responsible for the segmentation of higher-layer information into a size suitable for the information field of an ATM cells and the reassembly of the contents of a sequence of ATM cell information field into higher-layer information on reception.
- The **convergence sublayer** is an interface speecification. It defines the services that AAL provides to higher layers.

SONET/SDH

- Synchronous Optical Network (SONET) is an optical transmission interface originally proposed by BellCore and standardized by ANSI.
- ITU-T's compatible version called Synchronous Digital Hierarchy (SDH)
- intends to provide a specification for taking advantage of high-speed digital transmission capability of optical fiber
- SONET defines a hierarchy of standardized digital data rates
  - The lowest level is STS-1 (Synchronous Transport Signal, level 1) or OC-1 (Optical Carrier level 1) at 51.84 Mbps.
    - To carry a single DS-3 signal or a group of lower-rate signals (DS1, DS1C, DS2)
  - Multiple STS-1 form an STS-N by interleaving *N* synchronized STS-1 signals
- In SDH, the lowest rate is 155.52 Mbps designated STM-1 (corresponds to SONET STS-3)
- SONET/SDH are categorized in synchronous time-division multiplexing schemes.